

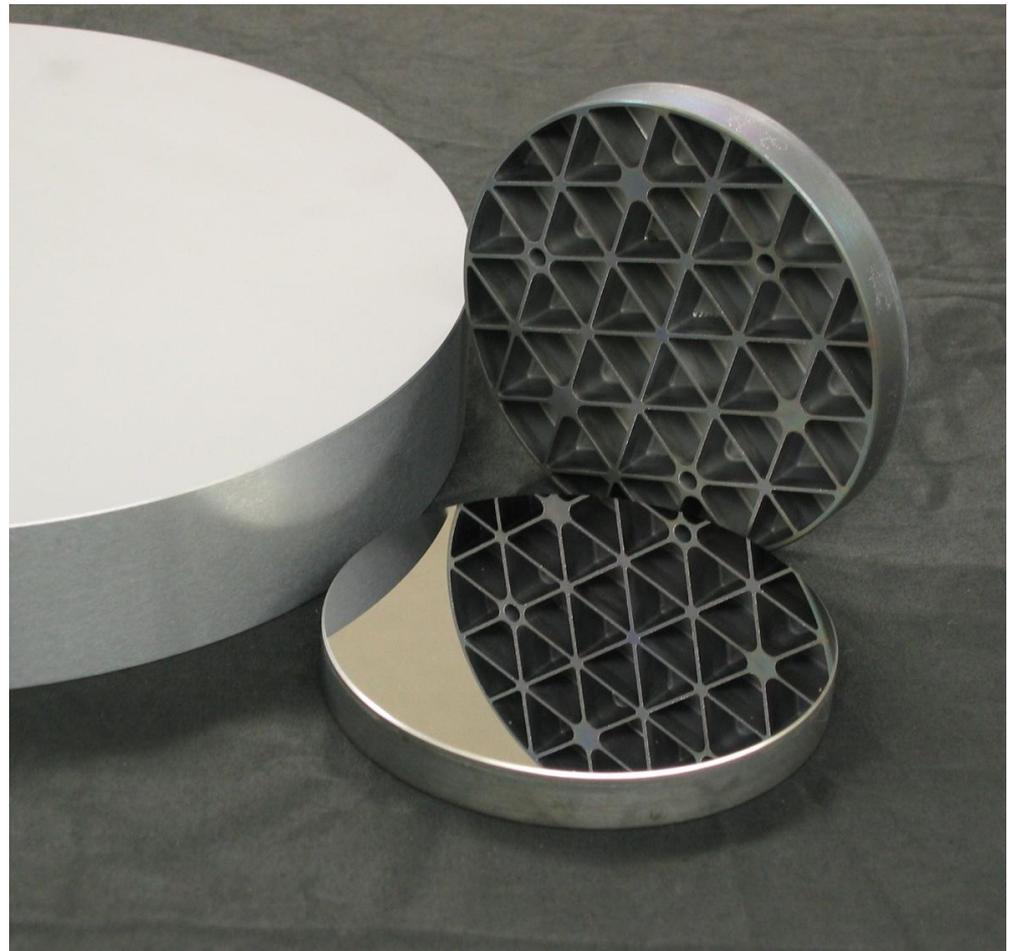
Single Crystal Silicon Light Weight Mirrors



Vince Bly Goddard Space Flight Center NASA

Topics:

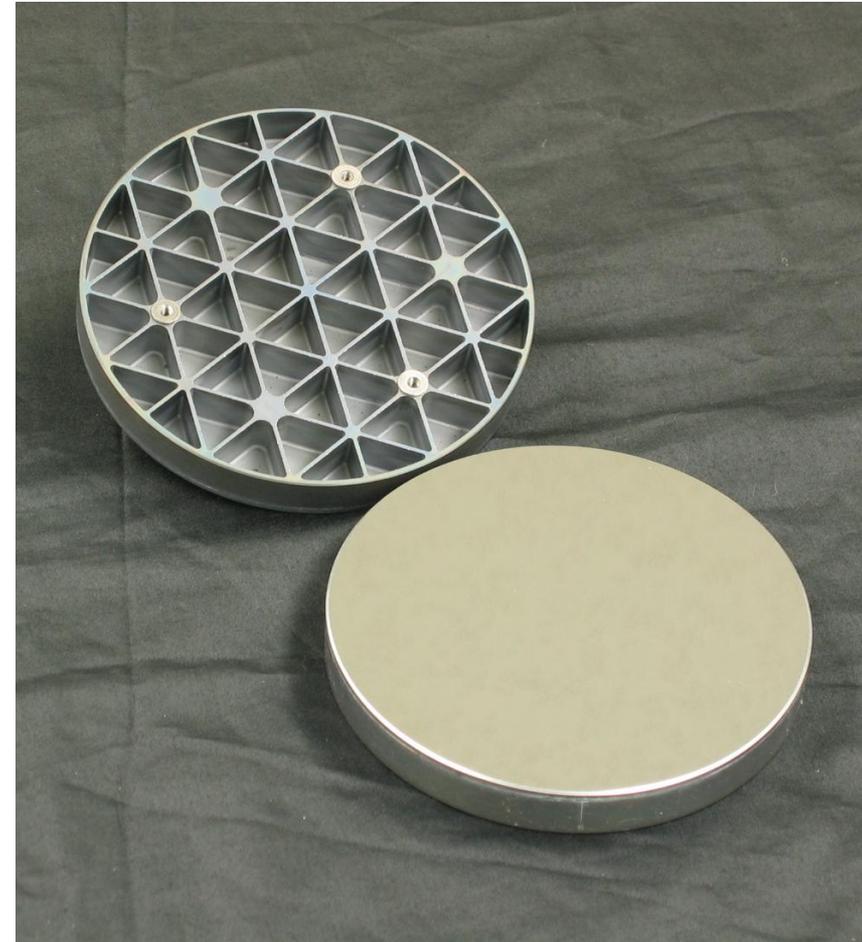
- Brief review of current process & previously published results
- Results of cryogenic testing
- Results on 10" (25 cm) mirror
- An avenue to very light weight SCS mirrors



Single Crystal Silicon Light Weight Mirrors



- Simple fabrication process
- Each mirror is a monolithic structure from a single crystal
- Excellent surface figure; typically better than $\lambda/50$ RMS
- Excellent resistance to thermal distortion, especially at cryogenic temperatures



Single Crystal Silicon Light Weight Mirrors



Fabrication Process:

- Cut blank from single crystal silicon boule
- Heat treat
- Grind & polish solid blank using conventional techniques
- Attach Pyrex protector
- Lightweight using ultrasonic machining
- Remove protector & heat treat



Single Crystal Silicon Light Weight Mirrors



Lightweighting Process

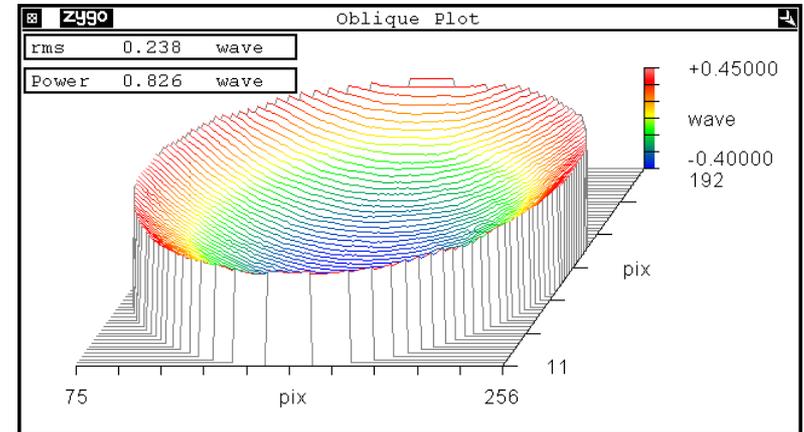
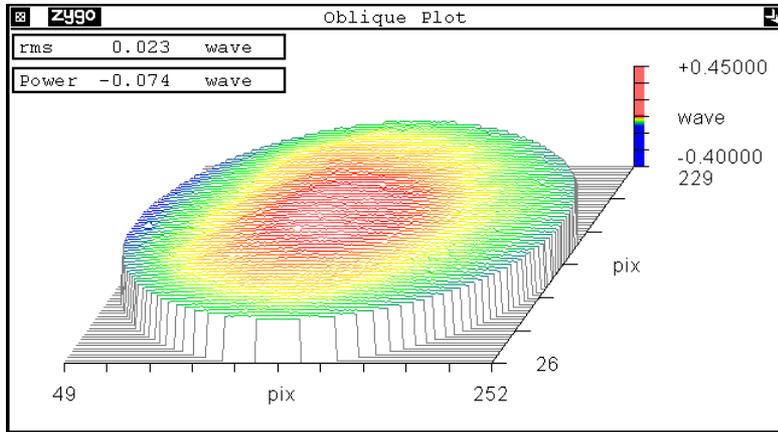
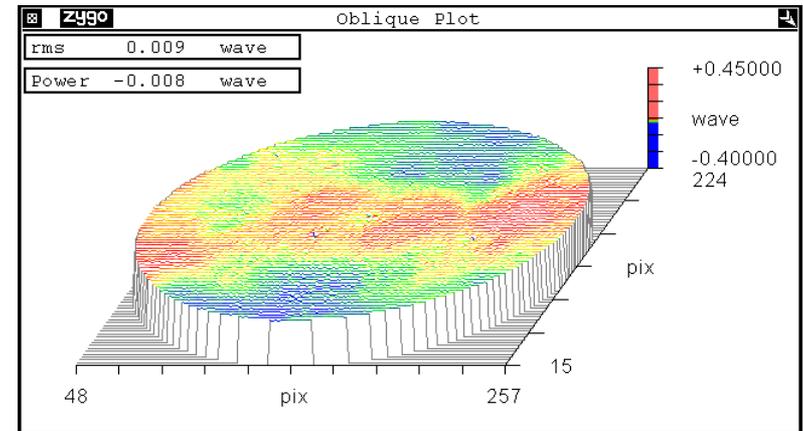


Figure before lightweighting

Figure after lightweighting,
before heat treating

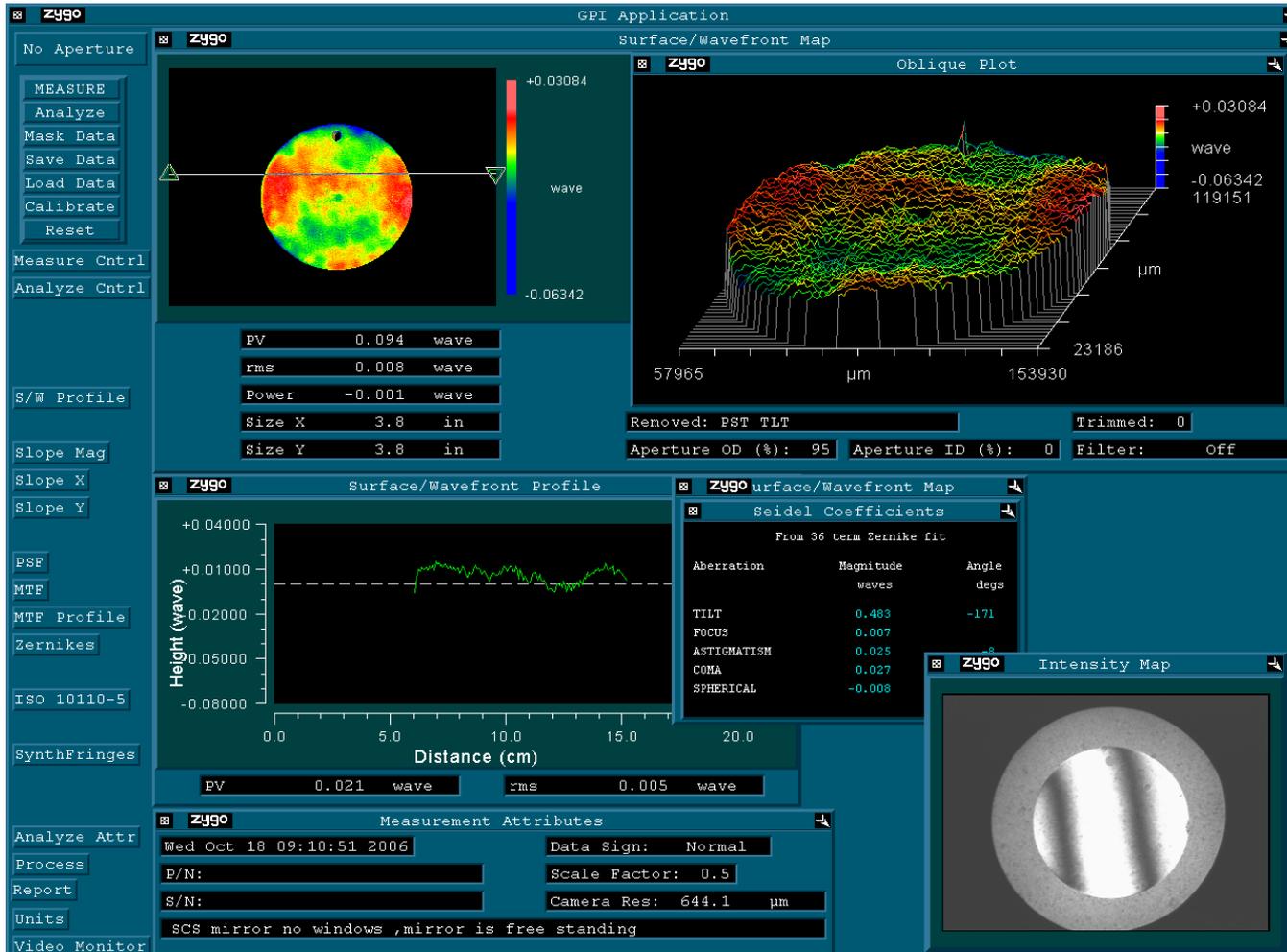
Figure after heat treating



Single Crystal Silicon Light Weight Mirrors



Interferogram of 10cm (4") SCS Flat #2C



Single Crystal Silicon Light Weight Mirrors



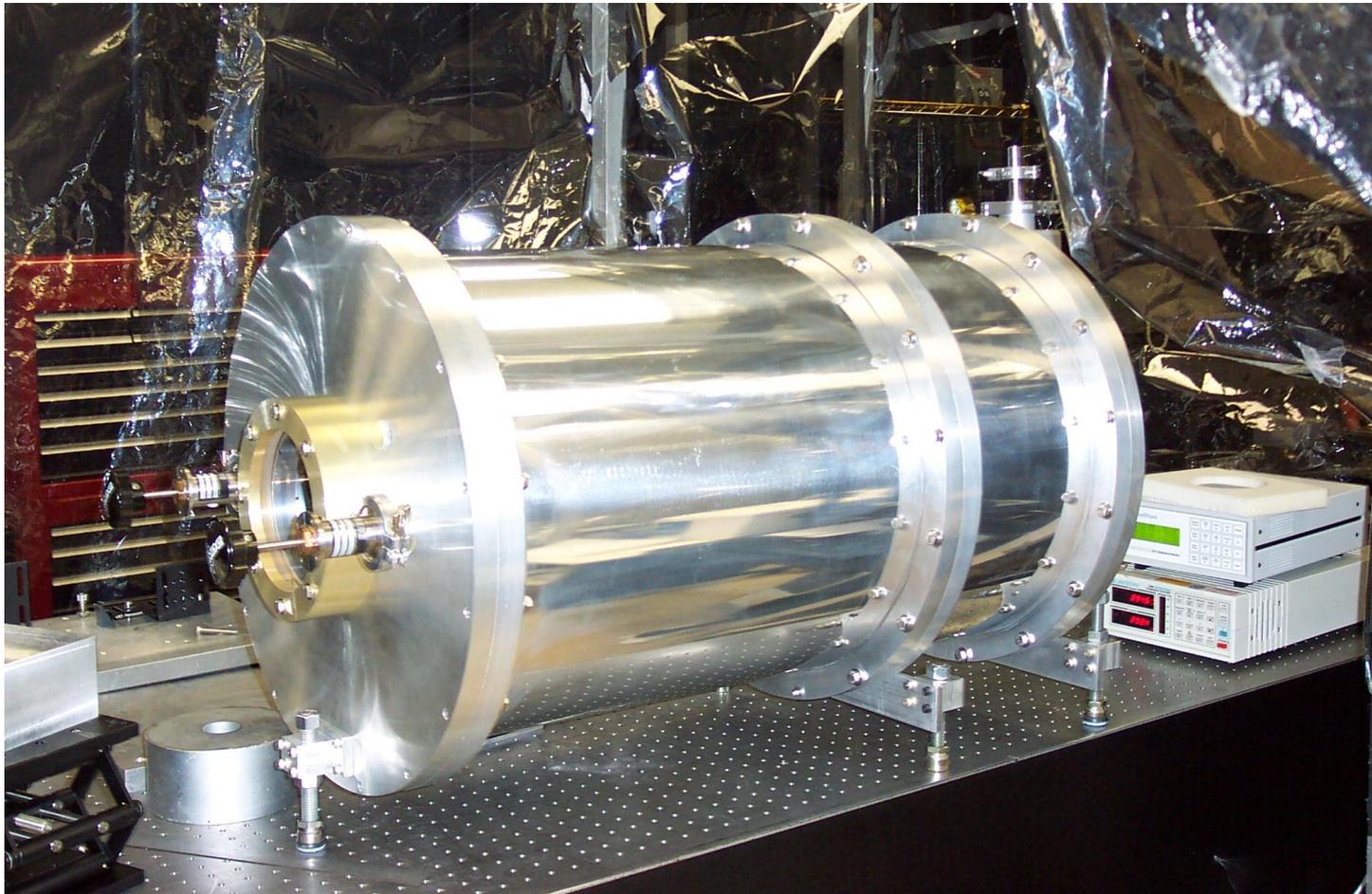
For more detailed information, see:

Lightweight instrument mirrors from single crystal silicon, V. T. Bly et al., Space Telescopes and Instrumentation I: Optical, Infrared, and Millimeter, May 2006, SPIE Vol. 6265 Part One

Single Crystal Silicon Light Weight Mirrors



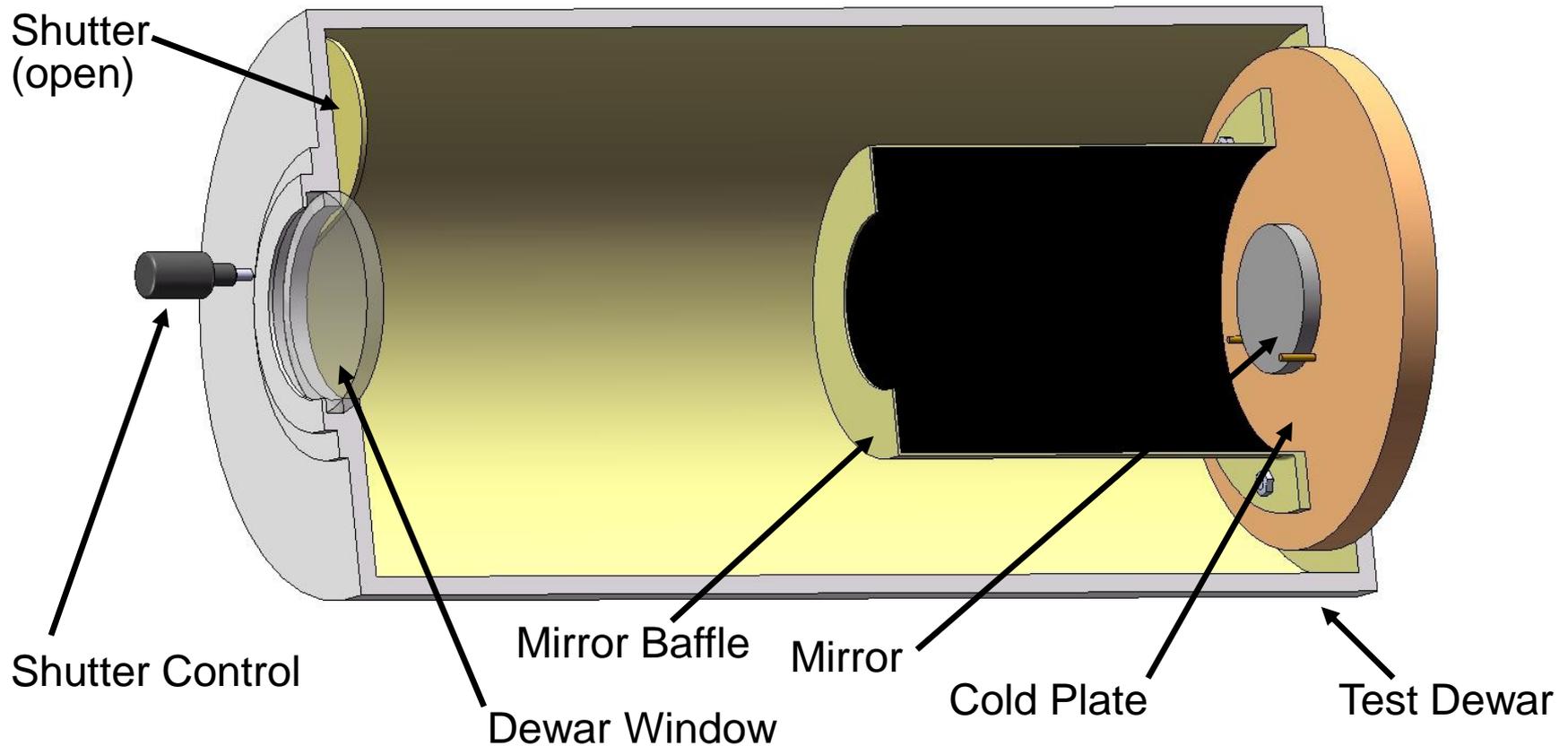
Cryogenic Test Facility



Single Crystal Silicon Light Weight Mirrors



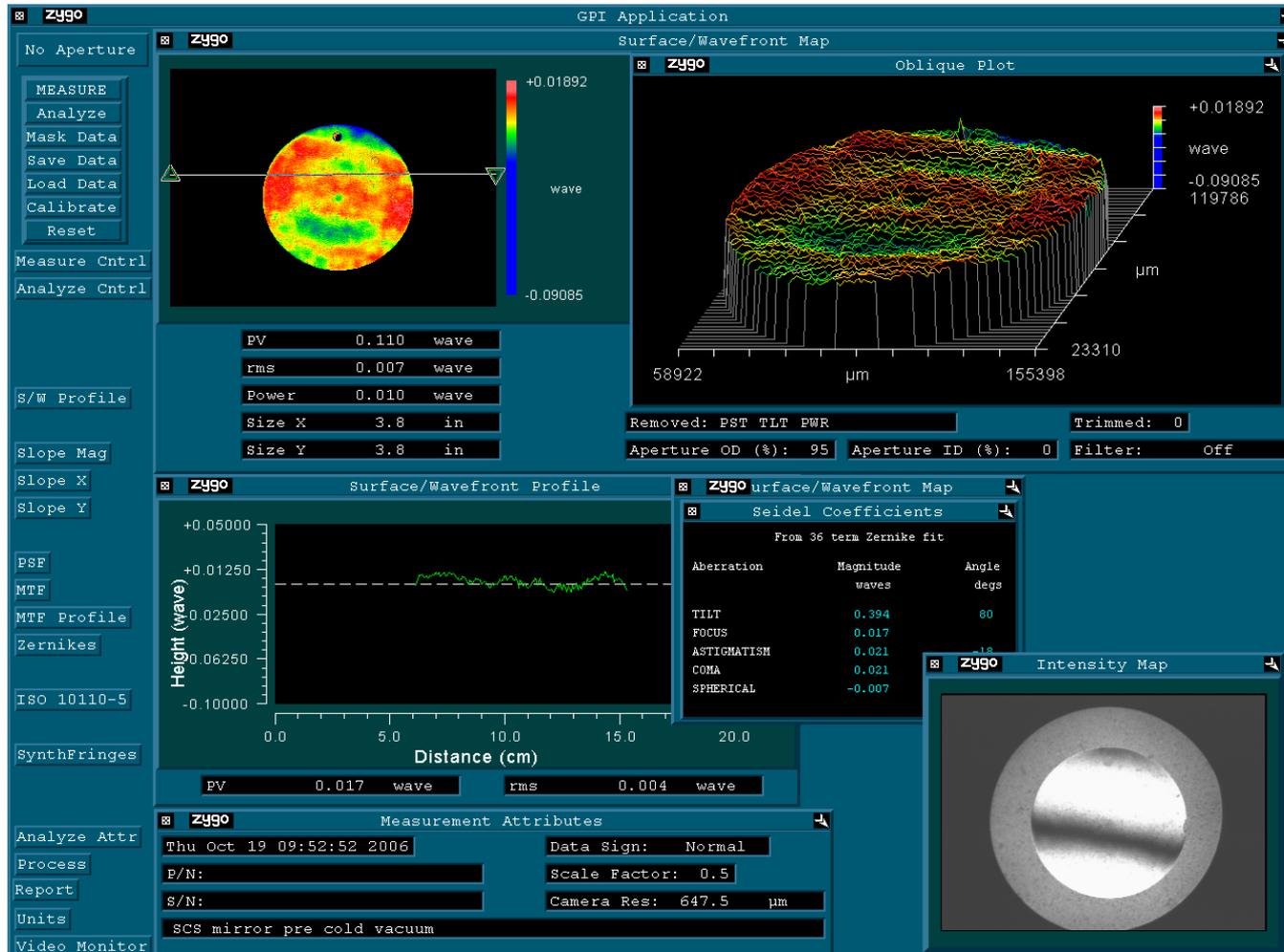
Cryogenic Test Facility – Component Layout



Single Crystal Silicon Light Weight Mirrors



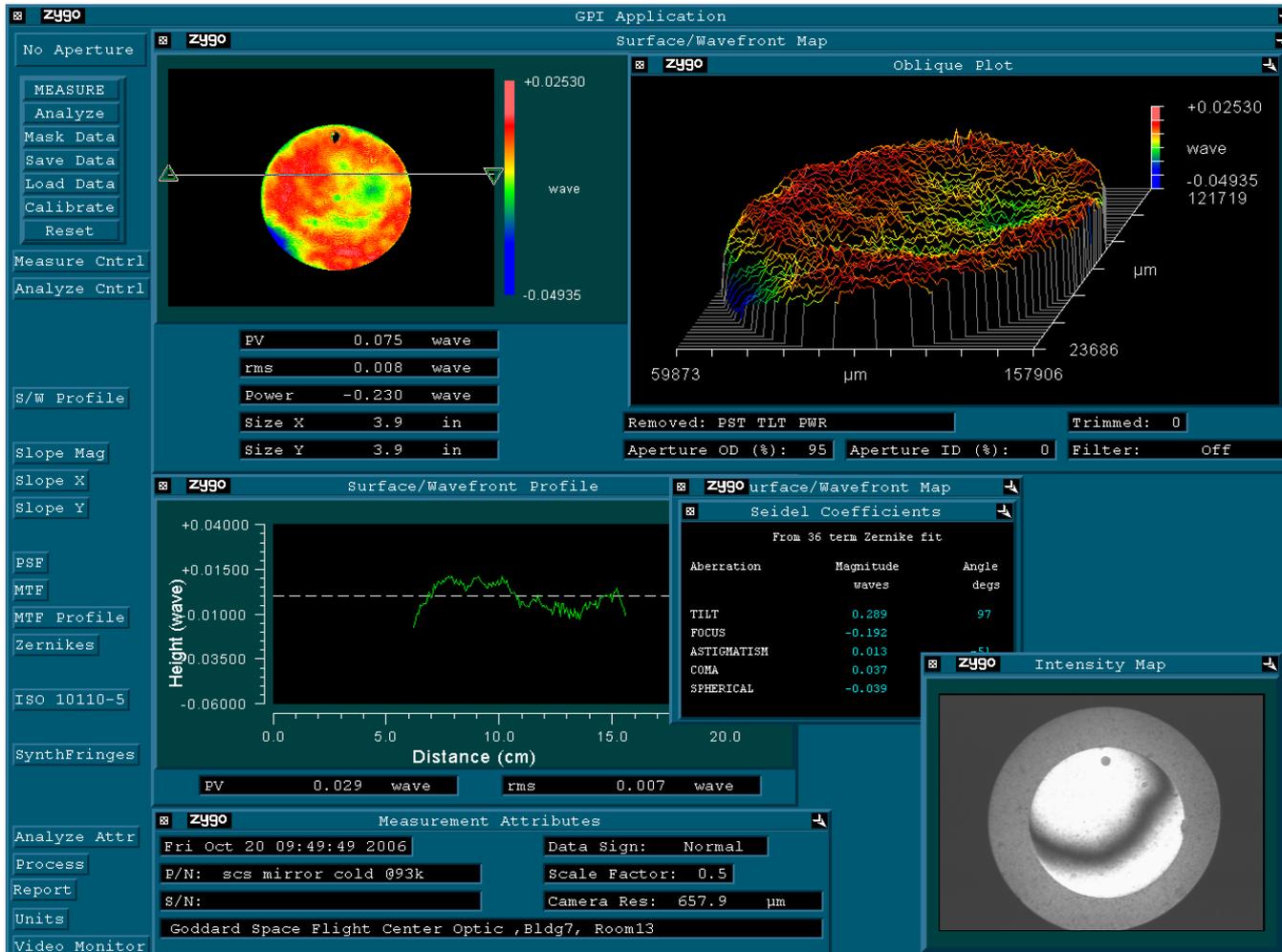
SCS Mirror 2C In Dewar at Ambient Temperature



Single Crystal Silicon Light Weight Mirrors



SCS Mirror 2C In Dewar at 83 Kelvin

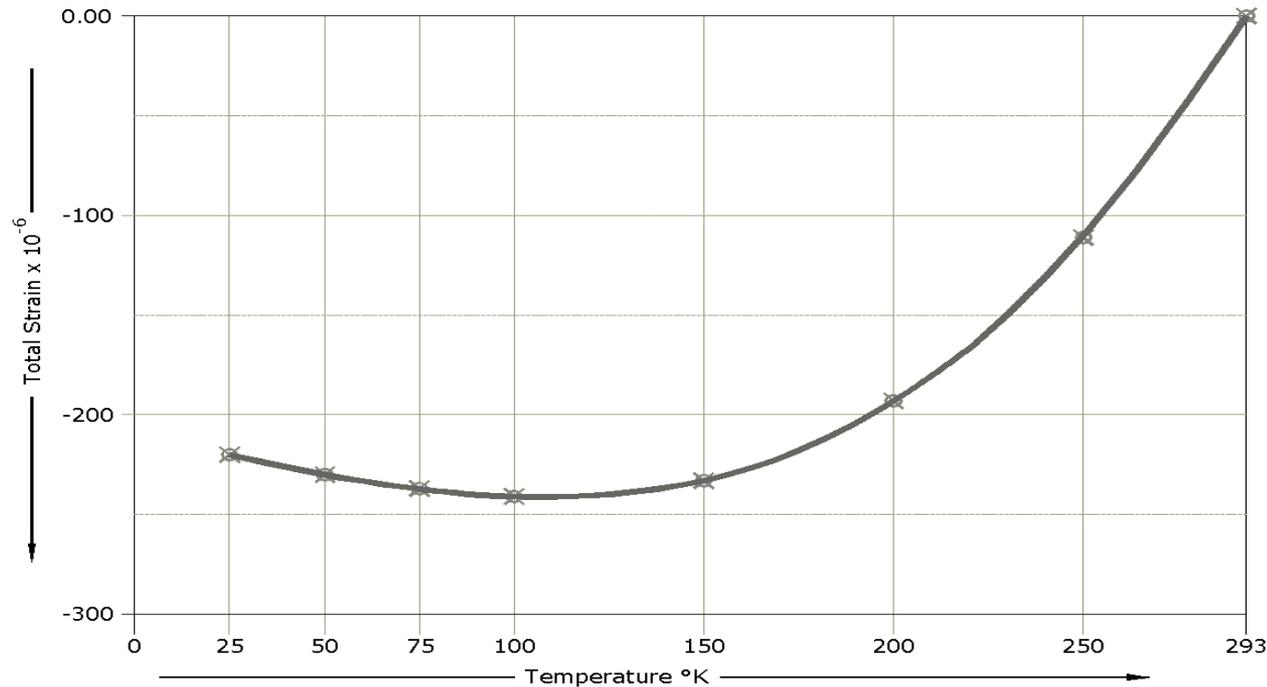


Single Crystal Silicon Light Weight Mirrors



SCS Mirror Cryogenic Distortion Test Summary

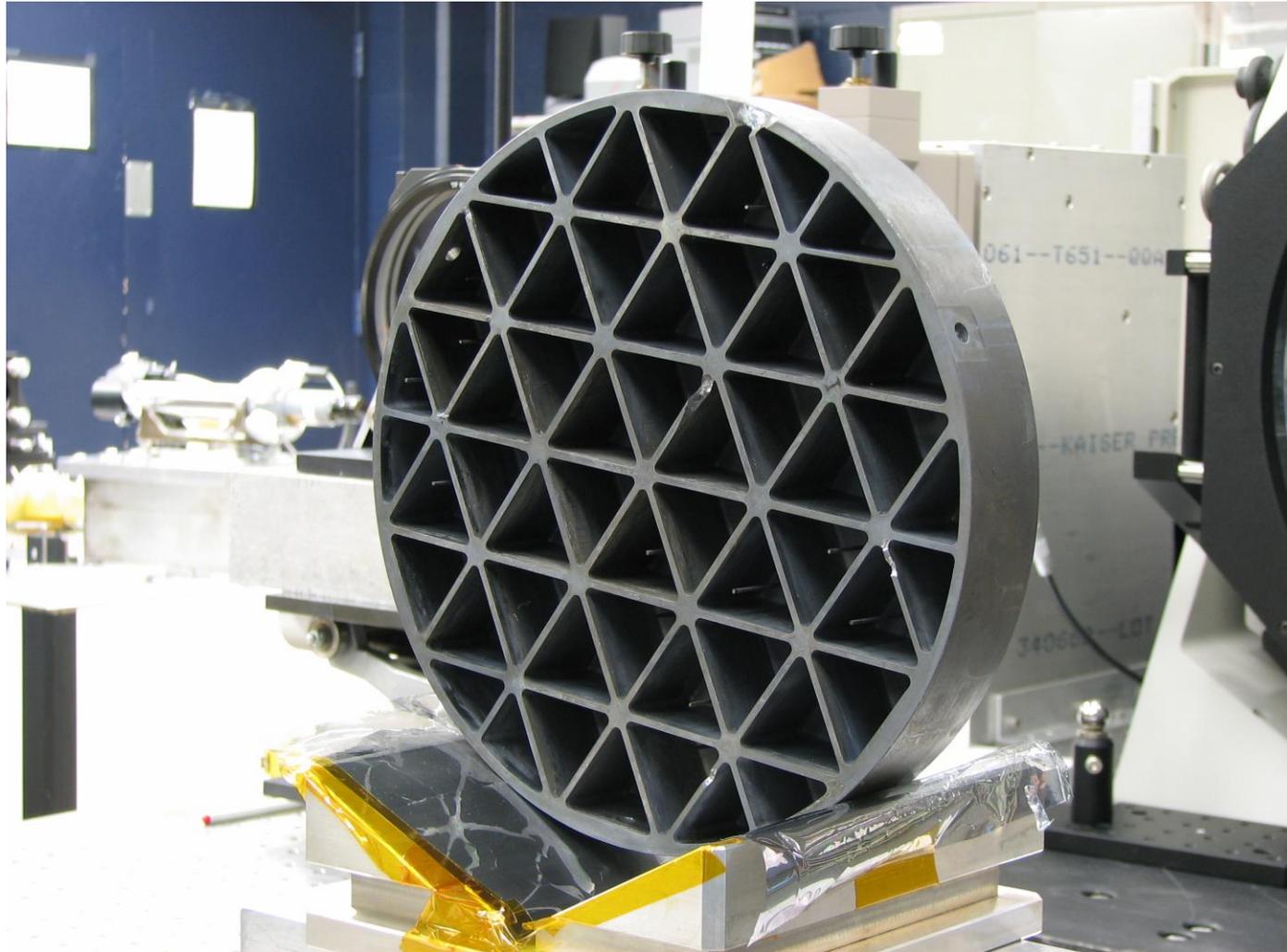
- Change with power removed = $0.001 \lambda \pm 0.002 \lambda$
- Change in power corrected for dewar window = 0.055λ



Single Crystal Silicon Light Weight Mirrors



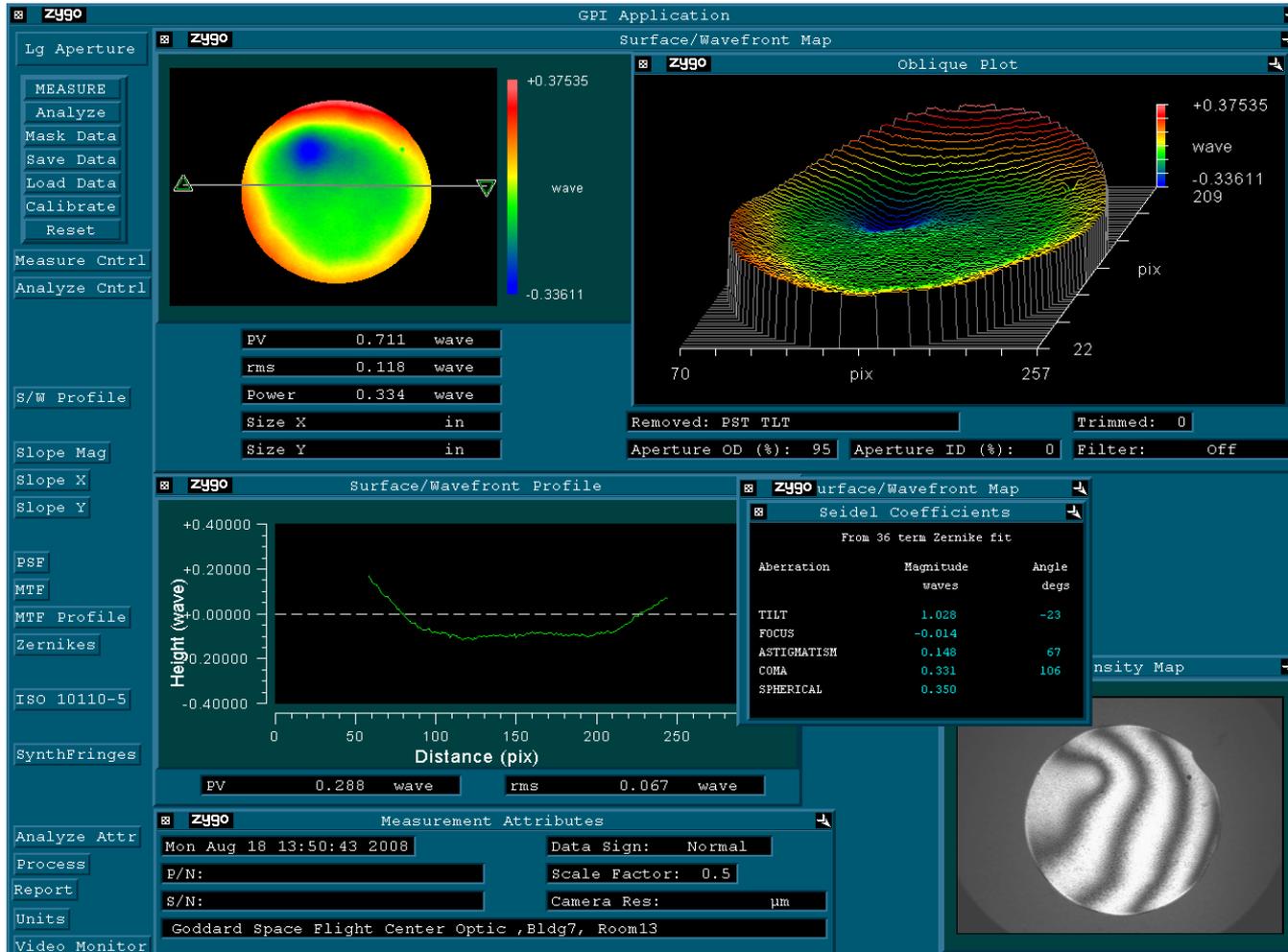
10" (24 cm) Diameter Single Crystal Silicon Mirror



Single Crystal Silicon Light Weight Mirrors



25 cm (10") Diameter Single Crystal Silicon Mirror



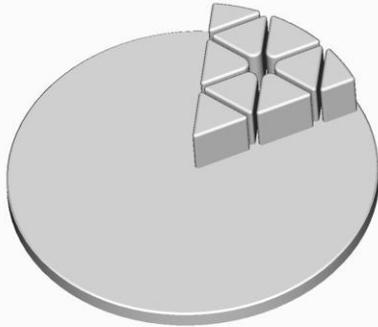
Single Crystal Silicon Light Weight Mirrors



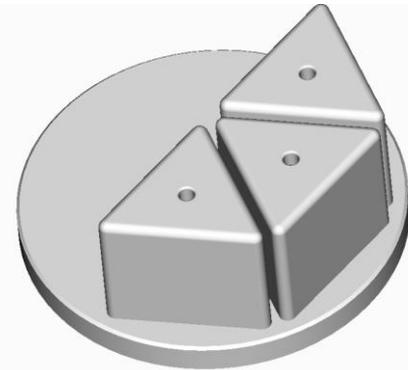
10" (24 cm) Diameter Single Crystal Silicon Mirror

The Primary Problem is how best to remove material from the light weighting pockets now that the volume is 15X larger.

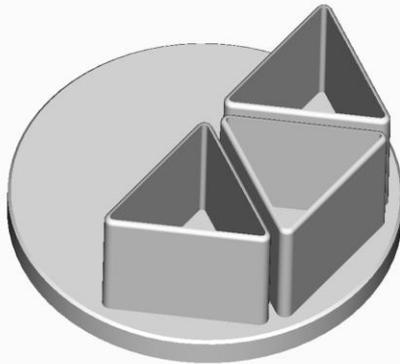
Small →
Mirror Tool



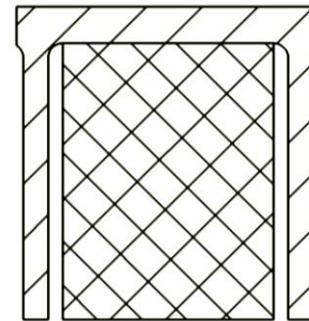
Original
10" Mirror
Tool →



Revised
10" Mirror
Tool 1 →



X-Section
of 2-Step
w/Revised
Tool Set



Single Crystal Silicon Light Weight Mirrors



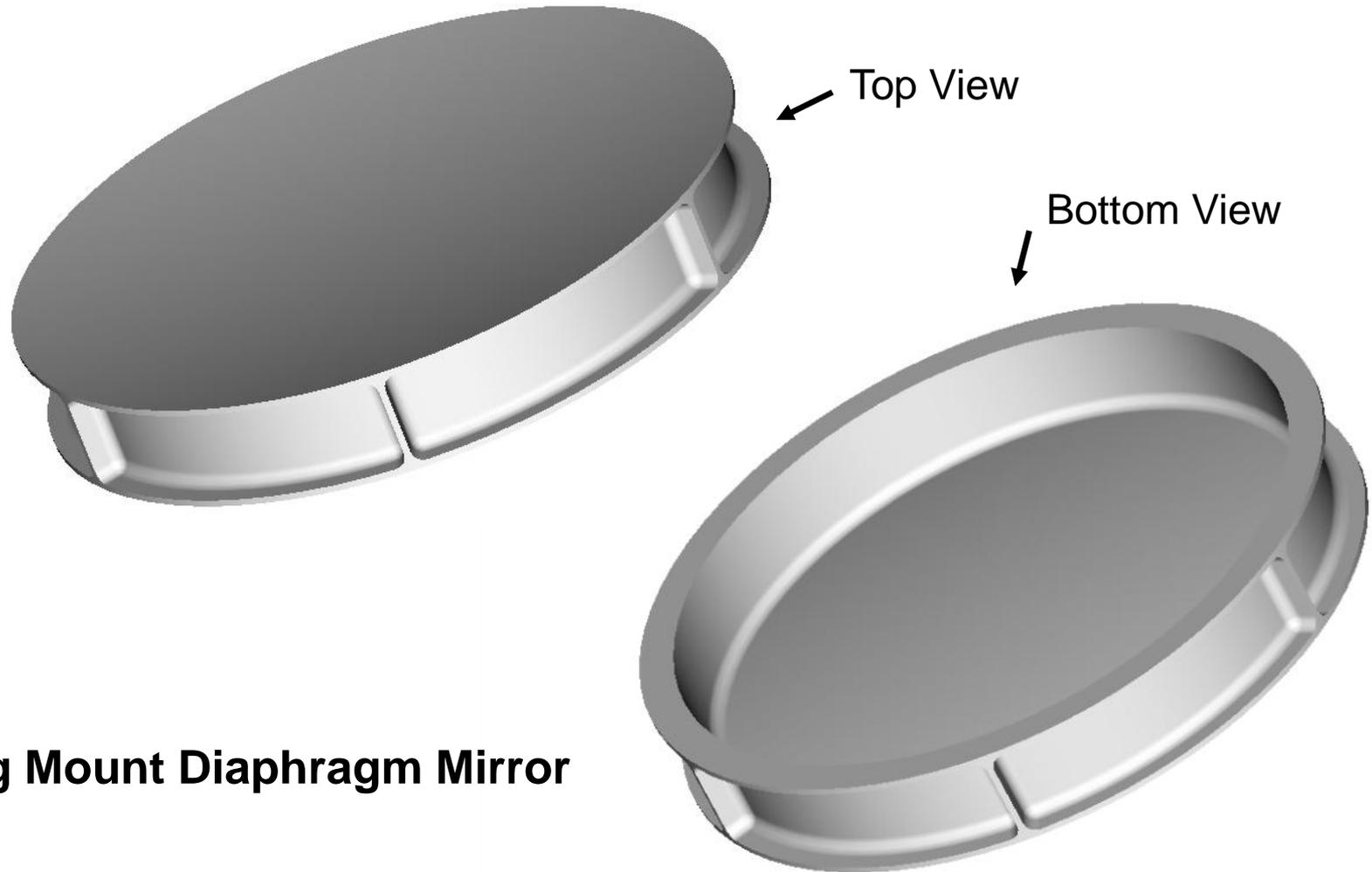
Extreme Light Weight Designs (10 to 1 or greater)

- The greatest mechanical stress that a mirror encounters is the grinding and polishing of the optical surface.
- Since SCS mirrors are light weighted afterward, the light weight structure does not need to withstand these forces.
- This opens up a whole new avenue to light weight mirror structures that only need to resist self-weight distortion and the stresses induced by the mounting.

Single Crystal Silicon Light Weight Mirrors



Extreme Light Weight Designs (10 to 1 or greater)

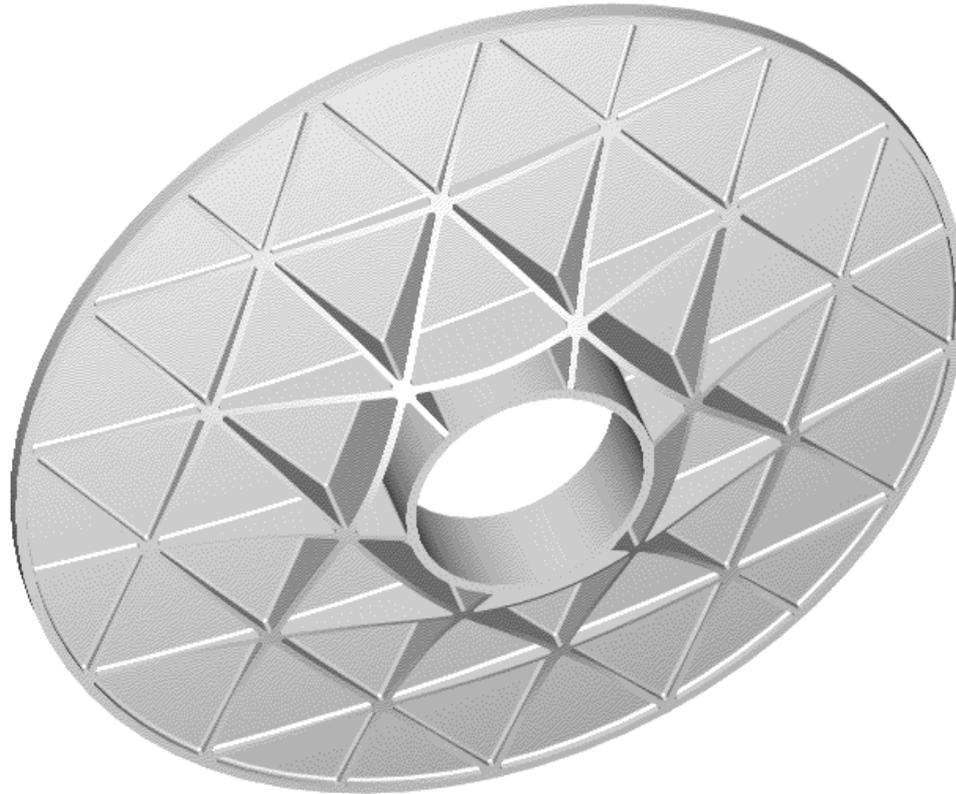


Ring Mount Diaphragm Mirror

Single Crystal Silicon Light Weight Mirrors



Extreme Light Weight Designs (10 to 1 or greater)



Light Weighted & Sculptured Back Perforated Primary